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ARCHITECTURE FOR ELECTRONIC IMAGERY INTEROPERABILITY

Autometric, Inc.

Ronald B. Haynes, Thomas A. Galayda, Mary B. DeMatteo

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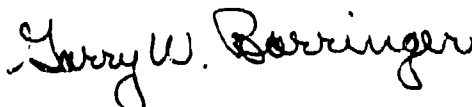Air Force Systems Command
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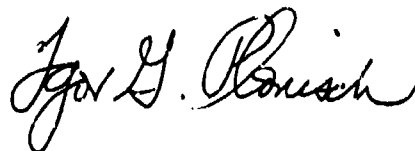RADC-TR-90-257 has been reviewed and is approved for publication.

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This report provides an overall description of an imagery interoperability architecture, being reviewed for implementation by the Office of the Secretary of Defense for Command, Control, Communications and Intelligence (OSD/C3I). The architecture furnishes the means for interoperability among digital electronic imagery reconnaissance assets of the United States and of its allies. It identifies programs designed to establish interoperability through standards, formats, and limited hardware and software development. These programs rely upon the unique properties of digital electronics used in new "softcopy" sensor exploitation systems as they replace traditional film based systems.

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PREFACE

This paper describes an imagery interoperability architecture, adopted by the Air Force, which is being reviewed for Department of Defense (DoD) implementation by the Office of the Secretary of Defense for Command, Control, Communications and Intelligence (OSD/C^{3}I). The architecture furnishes the means for interoperability among digital electronic imagery reconnaissance assets of the United States and its allies. It identifies programs designed to establish interoperability through standards, formats, and limited hardware and software development. The architecture and programs described herein take full advantage of special benefits provided by digital electronics to establish the needed interoperability, broaden mission options, and reduce costs.

The Image Exploitation Branch of the Rome Air Development Center's Intelligence and Reconnaissance Directorate is the program office responsible for the Interoperability Architecture. The address is RADC/IRRE, Griffiss AFB, New York, 13441-5700.

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SECTION I

INTRODUCTION

Tactical forces are in a transition from film-based imagery reconnaissance and surveillance sensor systems to digital, "softcopy" electronic systems. The Advanced Tactical Air Reconnaissance System (ATARS) program is developing and procuring the electronic sensors and data link capability to collect and transport imagery to exploitation systems. ATARS sensors and data links will be employed on a variety of platforms, both manned and unmanned, within the U.S. armed services. The Joint Service Imagery Processing System (JSIPS) program is developing and procuring the receive, exploitation, and reporting system for these electronic imagery systems. JSIPS will serve as the exploitation station for ATARS as well as other collection systems, both electronic and conventional.

Digital electronics, used in the new systems, is the key factor which provides the basis for new system employment concepts to improve the responsiveness and timeliness of the reconnaissance intelligence cycle, and to broaden its available sensor base. The broad-based use of digital sensors even makes development of a "common" exploitation station practical. But interoperability must first be established among the digital imagery systems for this to occur. Digital sensor data is recorded on tape cassettes. These cassettes are manually delivered to exploitation facilities, much as film was delivered in the past. Digital sensor data can also be transmitted via data link to surface facilities to speed the delivery and exploitation of priority imagery. This interface point, collection system (aerial component) to exploitation system (surface component), is the optimum point to focus an interoperability program (Figure 1). Interoperability at this point requires standardization of the tape recorder/cassette, data links, and data formats (Figure 2). The use of this interface point for system interoperability was validated in the 1986 Air Force Systems Command (AFSC) F-16(Reconnaissance) test at Edwards AFB, California.[1]

Data format, tape cassette, and data link standards alone will not provide full imagery system interoperability. Full interoperability needs to include non-standard systems, - those under development or currently deployed. Modifying these systems to meet new standards is cost prohibitive. The cost effective means here is to reformat their imagery information data, making it compatible with other systems.

Finally, a program to address the unique imagery processing requirements of synthetic aperture radar (SAR) systems would complete the interoperability process among digital electronic imagery systems.

Considering broadening mission options, AFSC's Rome Air Development Center (RADC), in a report entitled "F-16
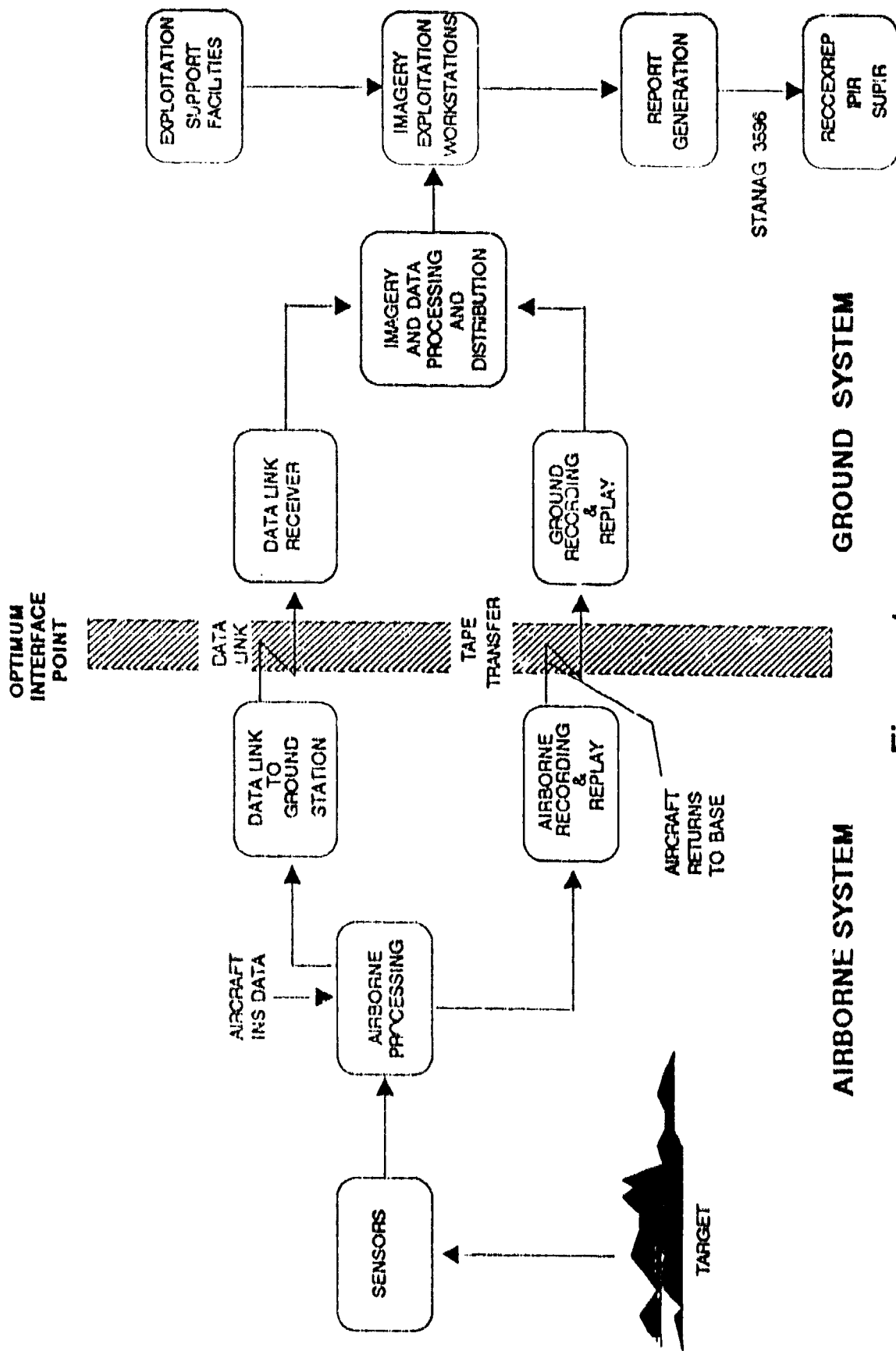
Figure 1

Optimum Interface Point to Design Interoperability into Softcopy Systems

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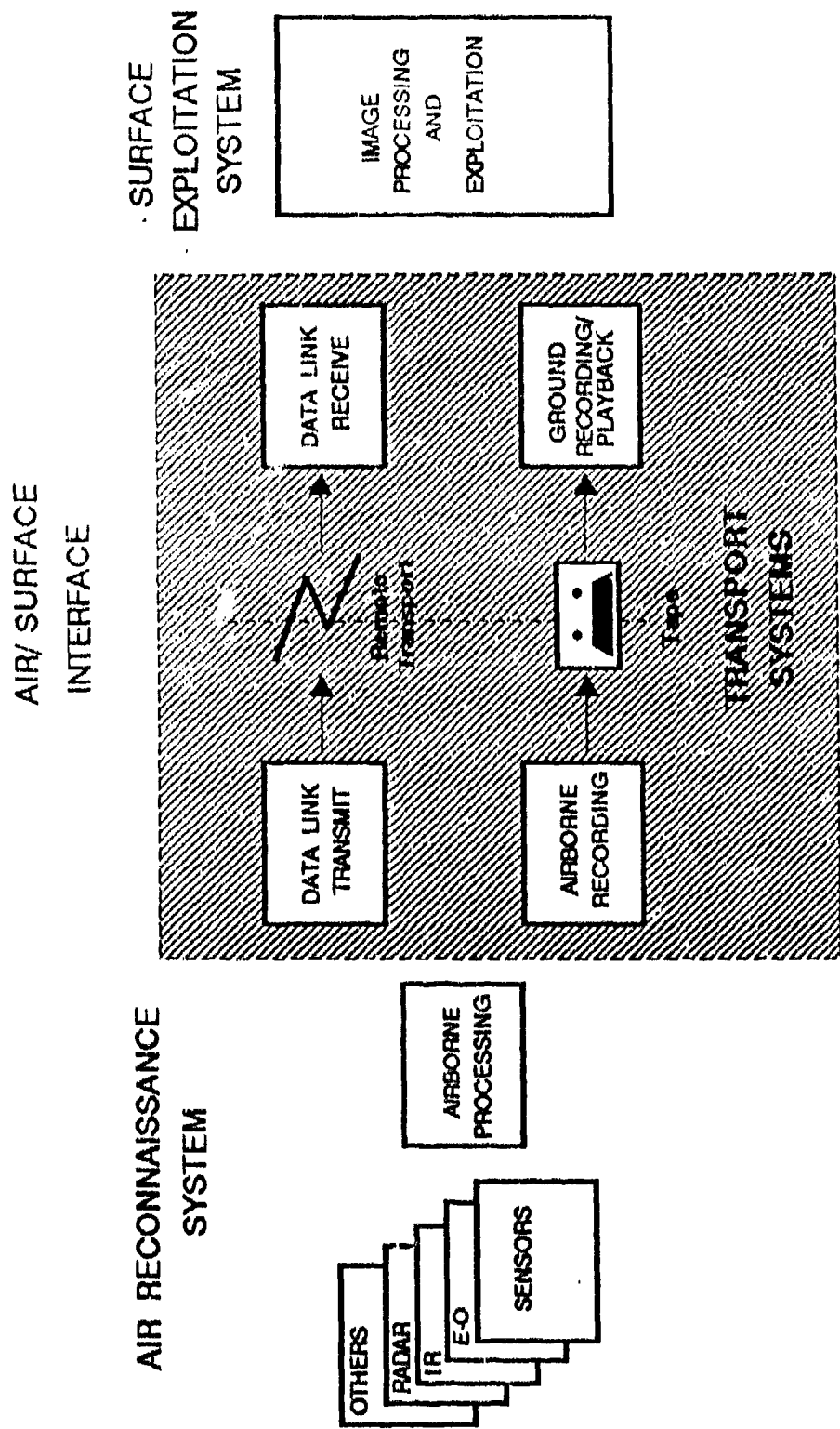
Figure 2
Transport Media at the Optimum Interface Point

Reconnaissance Ground Exploitation Concept Validation"[1], concluded that the availability of data link greatly expands concept options for the flexible deployment and employment of exploitation stations. This improvement results from data link eliminating the traditional need to collocate airborne collection assets and exploitation/reporting facilities. With data link, imagery exploitation stations can be positioned where they are most needed, and receive data directly from collection systems.

System interoperability, and the broadened flexibility in employment and deployment options resulting from elimination of the need to collocate exploitation and collection systems, make feasible development of a "common" ground station to exploit imagery from any and all digital sources. Figure 3 illustrates this concept.

The architecture for digital imagery system interoperability was developed by the Air Force through an effort called the Common Architecture for Reconnaissance Systems (CARS). Engineers from RADC performed the multi-year analysis which resulted in the architecture. The architecture was developed in close coordination with the ATARS and JSIPS program offices, and the U.S. Navy. It has been adopted by the Air Force and is being considered for Department of Defense (DoD) implementation by the Office of the Secretary of Defense (OSD) for Command, Control, Communications and Intelligence (C^3I).

RADC continues to be responsible for the overall imagery interoperability architecture, and is responsible for a number of its sub-programs. The program office for the architecture is RADC's Image Exploitation Branch, RADC/IRRE, Griffiss AFB, New York, 13441-5700.

Coordination of efforts with NATO have resulted in a complementary architecture for interoperability among all allied systems.
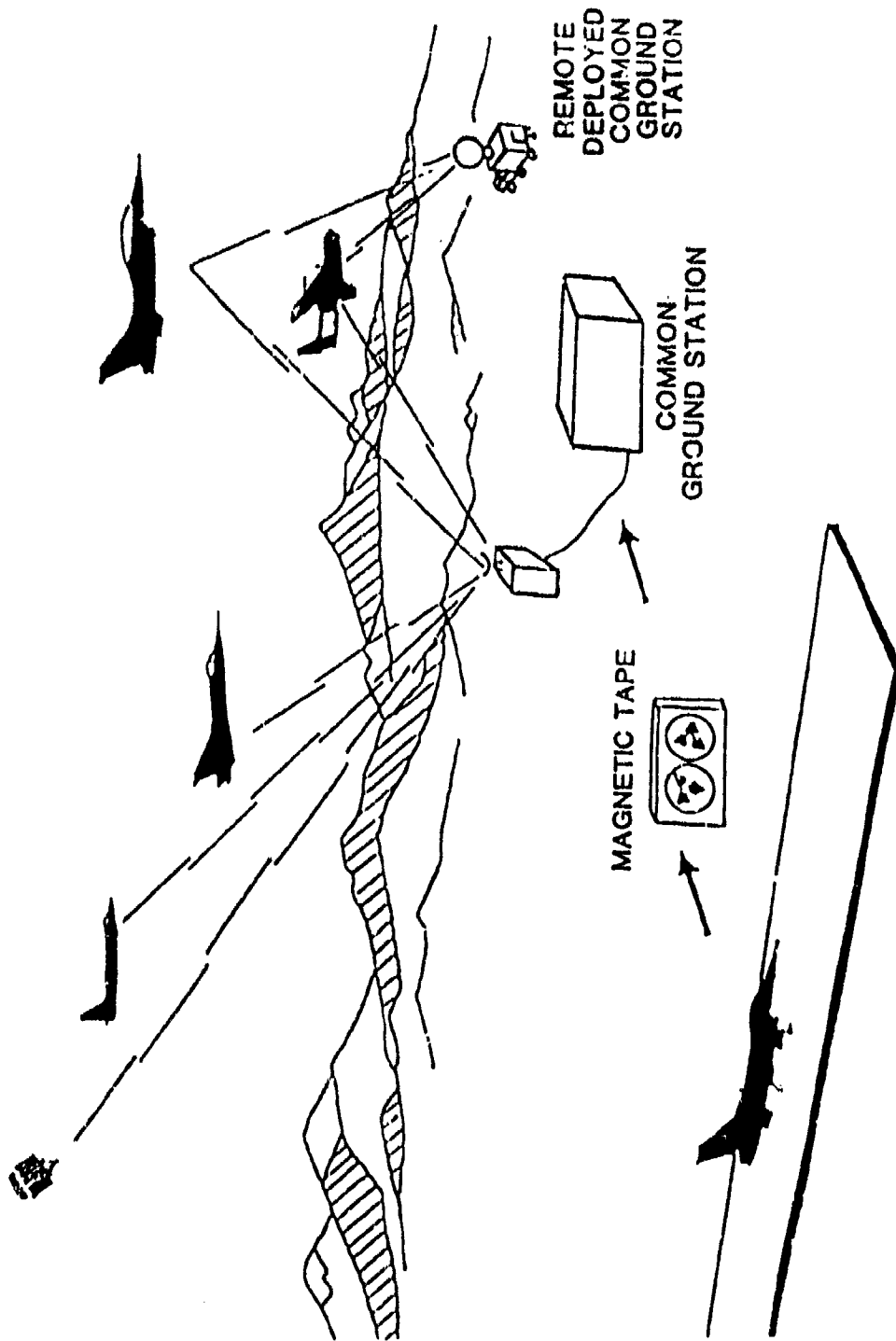
Figure 3
Common Ground Station Concept Under the Interoperability Architecture

REMOTE
DEPLOYED
COMMON
GROUND
STATION

COMMON
GROUND STATION

MAGNETIC TAPE

SECTION II

ARCHITECTURE FOR INTEROPERABILITY

The Air Force architecture addresses five areas, or required technical elements. Three elements require specifications and standards, and two, some hardware and software development (Figure 4). This section discusses these elements and specific programs for each (Figure 5). The architecture furnishes the ability to transport, display, review, and exploit imagery from virtually any electronic imagery sensor to interoperable exploitation stations.

1. THREE STANDARDIZATION ELEMENTS. The three elements identified for standardization by the architecture and programs for standardization are:

a. RECORDER / CASSETTE STANDARDS. The first element is physical standardization of the tape recorder and cassette used for on-board recording of imagery and auxiliary reconnaissance data, and its ground based playback.

Military Standard 2179A (MIL-STD-2179A), "Helical Digital Recording Format for 19mm Magnetic Tape Cassette Recorder/ Reproducers" was developed by the Navy for the Department of Defense. It specifies physical cassette dimensions, tape size, materials and principal properties, tape record locations, dimensions and orientation, a helical recording method and specifications, and the physical and electronic recorder - cassette interface for 19mm tape cassettes. MIL-STD-2179A is being expanded to include 8mm tape cassettes. MIL-STD-2179A provides the physical means to exchange digital data among reconnaissance systems and components.[2]

MIL-STD-2179A prescribes a single (serial) digital bit stream recorded and/or reproduced proportional to the input clock rate. It accommodates data rates from 10 to 480 megabits per second. It allows changes within data rates while maintaining a specified packing density and format at any speed. Tape speeds are variable and independent to input data rates.

MIL-STD-2179A records imagery data in a helical-scan format, with three tracks of supporting data recorded in a longitudinal format (Figure 6). The longitudinal tracks are used for annotation data, servo control, and time code or voice respectively.

b. IMAGERY DATA LINK COMPATIBILITY. The second element is data link compatibility. Data link standardization addresses system frequency, modulation, waveform characteristics, data rates, data formats, spatial directivity/link closure aspects, and security characteristics.

The interoperability architecture specifies the Common Data Link (CDL) program of the Defense Support Project Office (DSPO)

STANDARDS AND SPECIFICATIONS

Physical Tape Recorder/Cassette Standards

Data Link Standards for Compatibility

Imagery and Related Data Format/Architecture

HARDWARE, SOFTWARE, & STANDARDS/SPECS

Reformatting for Non-Standard Systems

SAR Imagery Processing

Figure 4

The Required Technical Elements in the Air Force's
Architecture for Electronic Imagery Interoperability

REQUIRED TECHNICAL ELEMENT	INTEROPERABILITY PROGRAM
Recorder/Cassette	— MIL-STD-2179A
Imagery Data Link	— Common Data Link (CDL)
Imagery/Data Formats	Reconnaissance Data Exchange Standard (RDES)
Reformatting for Non-Standard Systems	Imagery Information Reformatter (IIR)
SAR Imagery Processing	— Adaptive SAR Processor

Figure 5

Programs Addressing Specific Technical Elements

in the Air Force's Imagery Interoperability Architecture

Figure 6   MIL-STD-2179A   Physical Tape Format (19 mm)

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to satisfy the requirement. DSPO's CDL is designed to:

- maximize the military commanders ability to share intelligence assets,

- maximize flexibility in assigning assets to commanders,

- provide a rapid response to deliver intelligence to users,

- provide new options to respond to crisis situations and enemy threats, and,

- allow the use of worldwide intelligence assets.

DSPO's CDL specifies electrical, mechanical, and performance requirements through an end-to-end system using defined hardware and software with specified functionality. CDL's hardware and software are modular. It makes data available from platforms and sensor suites without regard to traditional command levels, from National to tactical.[3]

CDL provides flexible worldwide deployment options. Control can be local to the theater or remote to distant command authorities through air-to-air or air-to-satellite real-time relays. Relays may also be used to extend local commander coverage. With CDL, platforms and intelligence sensors need not be theater specific. For example, a platform could support the European Theater or be shifted to support a Navy fleet exercise, or the Central Theater Commander without having to return to base. CDL allows the use of any or all combinations of satellites, high flyers, manned penetrators, and unmanned vehicles to achieve timely access of information and gain needed coverage of all areas of interest (Figure 7).

CDL command and data processing formats have been adopted by DSPO from RADC's Reconnaissance Data Exchange Standard (RDES). (RDES will be discussed next.)

Like CARS, the CDL architecture draws heavily from International Systems Organization (ISO) definitions and standards for Open System Interconnect (OSI). CDL modules were defined by the Air Force's Aeronautical Systems Division (ASD) from their Modular Avionics Systems studies.

DSPO's approach to data link interoperability is to:

- specify and direct interoperability through a series of "A" level segment documents, program funding assessments, and the creation of a high level government program;

- create a family of common modules that would adequately implement the specified standards and are flexible enough in terms of form, fit, and functionality to be useable on a variety of platforms and in a variety of operational
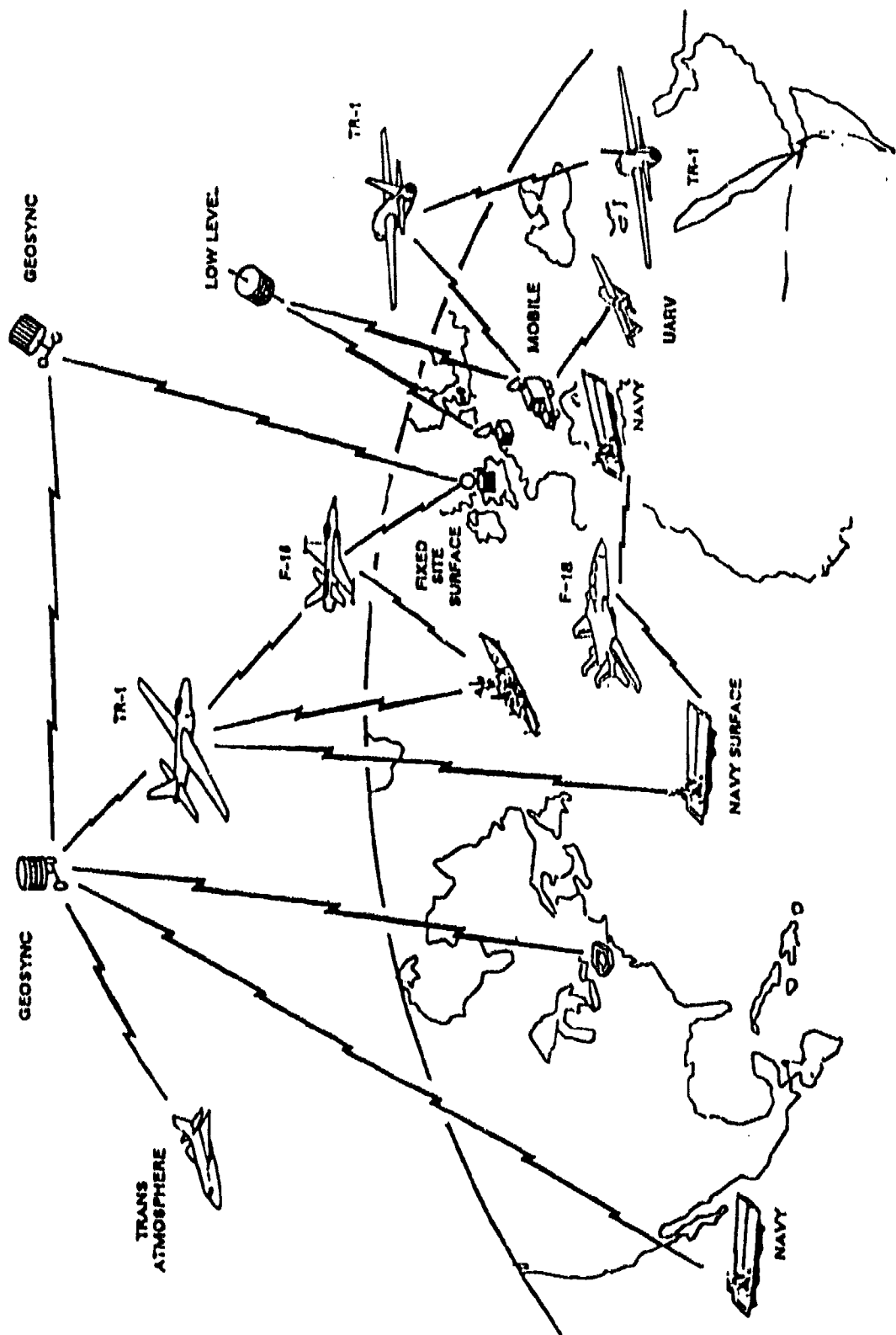
FIGURE 7
CDL DEPLOYMENT FLEXIBILITY

environments; and,

- create user documentation so that a true non-vendor
  specific implementation is achievable.

This approach allows for smaller numbers of intelligence assets
to respond to a maximum number of users without sacrificing
timeliness or availability at local command levels.

     c. **A STANDARD IMAGERY INFORMATION FORMAT.** Tape cassette
and data link standards will not provide interoperability
unless a standard format architecture is established for
imagery and auxiliary data.

The ability to access and interpret data from any collection
system needs to exist at the exploitation system. This ability
prevails if there is knowledge of the data's transport
architecture and format. Each collection system is capable of
transporting electronic data via a variety of architectures and
formats. Depending on the collection device used, imagery data
generated by a sensor system may vary greatly from that of
systems using different sensor devices. In these cases,
different data formats exist for each system, specific to the
particular system. Currently, these formats are transported
via independently developed transport architectures. The
destination exploitation system generally has the capability to
access data received via the specific transport architecture
designed for the system. To achieve interoperability, a
flexible and adaptable standard architecture is needed which is
capable of transporting these diverse data formats from any
collection system to any exploitation system. The standard
needs to include descriptions of all data formats utilizing
this architecture to enable exploitation systems to access and
interpret the data.

In addition to imagery data, exploitation systems require
auxiliary data concerning mission, location, orientation, etc.
This data is needed with the imagery data to adequately exploit
and report upon imagery received at the station. Adherence to
a standard architecture insures that all data required is
included in the data transport architecture and provided by the
collection system; see Figure 8. As a result, the requirements
of specific systems are being identified and incorporated into
an architectural design.

The Reconnaissance Data Exchange Standard (RDES)[4] establishes
the common imagery information exchange architecture and
standardized data formats for information compatibility among
reconnaissance systems. RDES is being developed by RADC for
submission to the Joint Chiefs-of-Staff for publication through
the Office of the Secretary of Defense.

RDES defines the structure and content of reconnaissance data
being moved to the magnetic tape or data link. The RDES
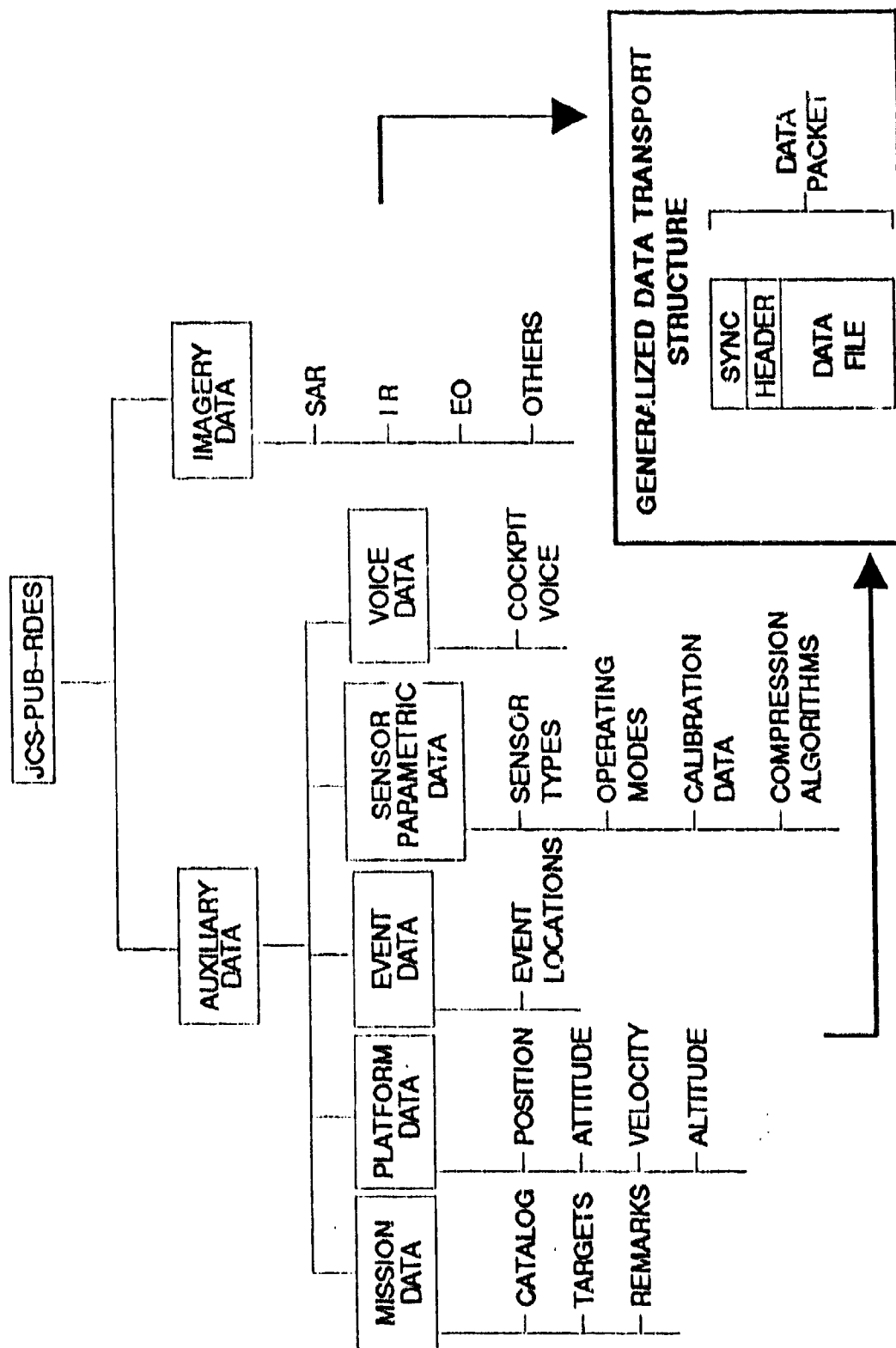document should not be confused with those generated by the

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Figure 8

Data Structure of the Reconnaissance Data Exchange Standard (RDES)

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Common Data Link Program or the Recorder/Cassette Program (MIL-STD-2179). These programs deal with aspects pertinent to data link and tape recorder configurations. RDES however provides the logical architecture for data to be transported via these configurations. Figure 9 illustrates the logical flow of data from tape record to data link using the RDES specified architecture. RDES does not address data rates, channelization, or physical limitations associated with the transport media. RDES rather addresses the logical requirements necessary to provide a common architecture used to transport data from any collection system to any exploitation system. RDES not only specifies the transport architecture but also defines the logical data formats specific to each type of collection system. The structure of the RDES document itself illustrates this concept. The basic document defines RDES's architecture and its appendixes specify the format required by each sensor's collection/exploitation system.

The general RDES data transport scenario consists of:

- access of a data file from a source block,
- assembly of the data file into a data transport packet,
- transport of the data packet across the media to the destination system,
- disassembly of the packet at the destination system, and,
- incorporation of the data file into the proper destination block (which is a replica of the source data block).

Sensor and auxiliary data are stored on the source and destination systems in block structures. Blocks are a set or collection of related digital data (such as mission data, collection platform data, sensor data, etc.) and are defined for the purposes of grouping associated data files. Each data file within a block in source memory is transported to the destination system via a data packet.

A data packet consists of three data structures, a synchronization code, a header, and the source data file (Figure 8). The synchronization code is a unique bit pattern used to signal the transport of a new packet to the destination system. Otherwise, the system would not be able to discern proper boundaries between packets. The header contains information about the data file. The header information includes parameters such as the type of data file; the data file length; block attributes such as the block file number, block length, etc. for purposes of source block structure replication at the destination; its relationship to other associated data files; and, miscellaneous information used to aid accessibility and eventual exploitation of the data.

The modularity of the RDES architecture allows the system designer to use only the data required to accomplish his
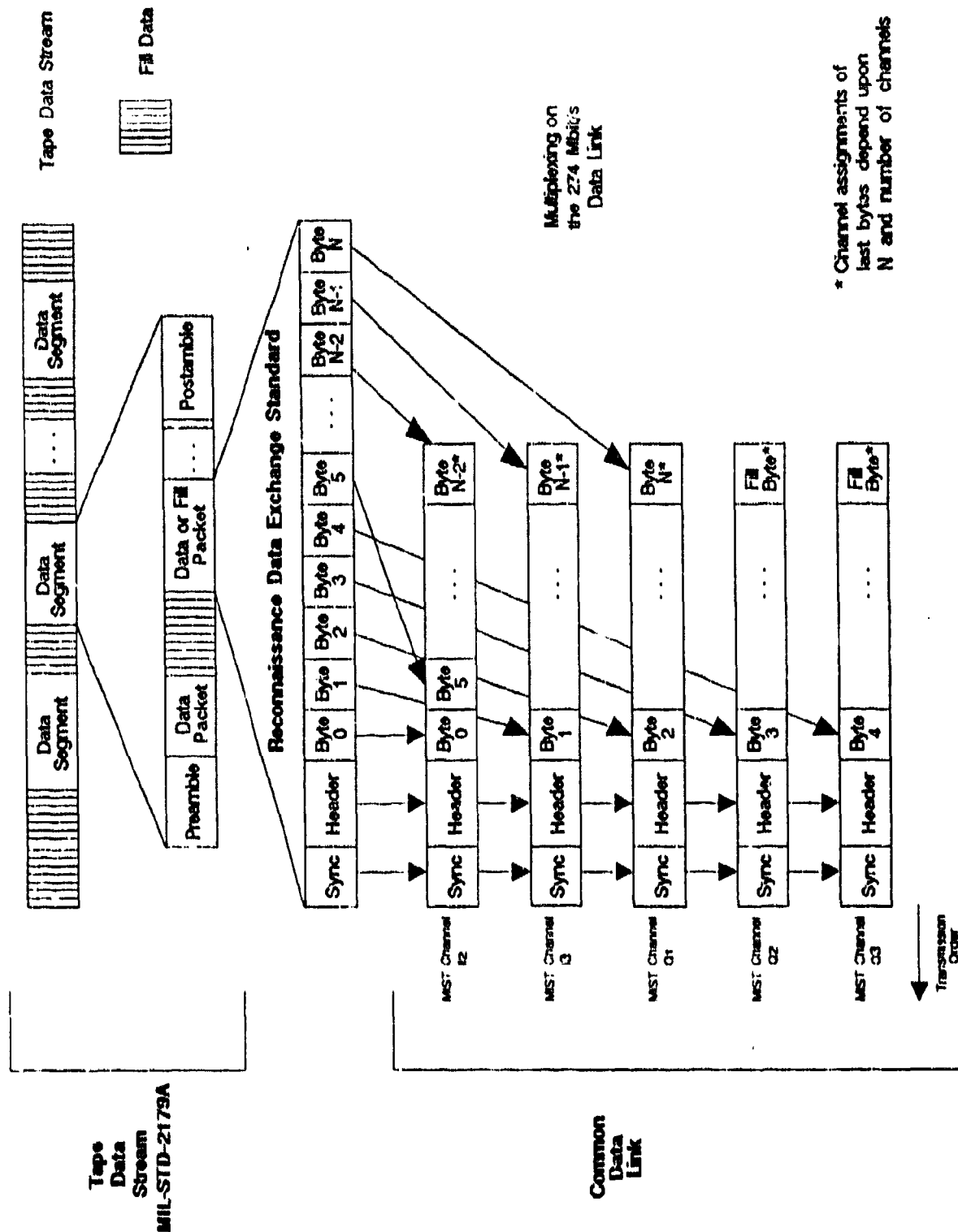
Figure 9
Logical Data Formats From Tape to Data Link [5]

particular mission. By using only what is required, the system designer can keep data overhead to a minimum and enjoy the benefits of greater efficiency.

RDES is designed to be flexible and adaptable to grow with technology. Extra area is reserved in the format for system enhancements, and the modular architecture allows for the incorporation of future systems.

2. ELEMENTS REQUIRING INTEROPERABLE SOLUTIONS BROADER THAN BASIC STANDARDS. Interoperability cannot be achieved through tape recorder/cassette, data link, and imagery/information format standards and specifications alone. Existing systems are not standard, and to modify them is simply not cost effective. Additionally, it can not be anticipated that all future systems will be built to standard. In addressing this technical element, the interoperability architecture identifies how these non-standard systems can be included.

The architecture concludes by addressing a fifth technical element to identify a means to provide interoperability among synthetic aperture radar (SAR) systems with their special imagery processing requirements.

Interoperable solutions in these two elements require some hardware and software development in addition to standards.

   a. REFORMATTING FOR NON-STANDARD SYSTEMS. The architecture here provides a method to access and display imagery data when that data is recorded or data linked in a format that is neither standard nor exploitable on available exploitation equipment. The existence of non-standard systems, and the potential for more, requires a method to "reformat" imagery data so it can be accepted and exploited on a recipient's particular exploitation system. Studies such as CARS showed that it is not cost effective to modify existing systems to be interoperable with each other system to accommodate new standards. Furthermore, the existence of a standard does not prohibit other agencies from using different standards. Multiple standards may be adopted by various government and commercial agencies based on such matters as mission and payload requirements. Thus, the Air Force architecture recommends the development of a reformatter device to provide interoperability for existing non-standard systems, and for systems which may remain unique or adhere to differing standards. The Imagery/Information Reformatter (IIR) Program is a cooperative, NATO sponsored joint French - U.S. effort addressing this aspect of the architecture. The program is developing a system to convert electro-optical imagery and auxiliary data from one format to another in near-real-time.[6]

IIR system design is shown in Figure 10. It includes a reformatter core, input/output (I/O) busses, and I/O interface modules which consist of one or two printed circuit boards.
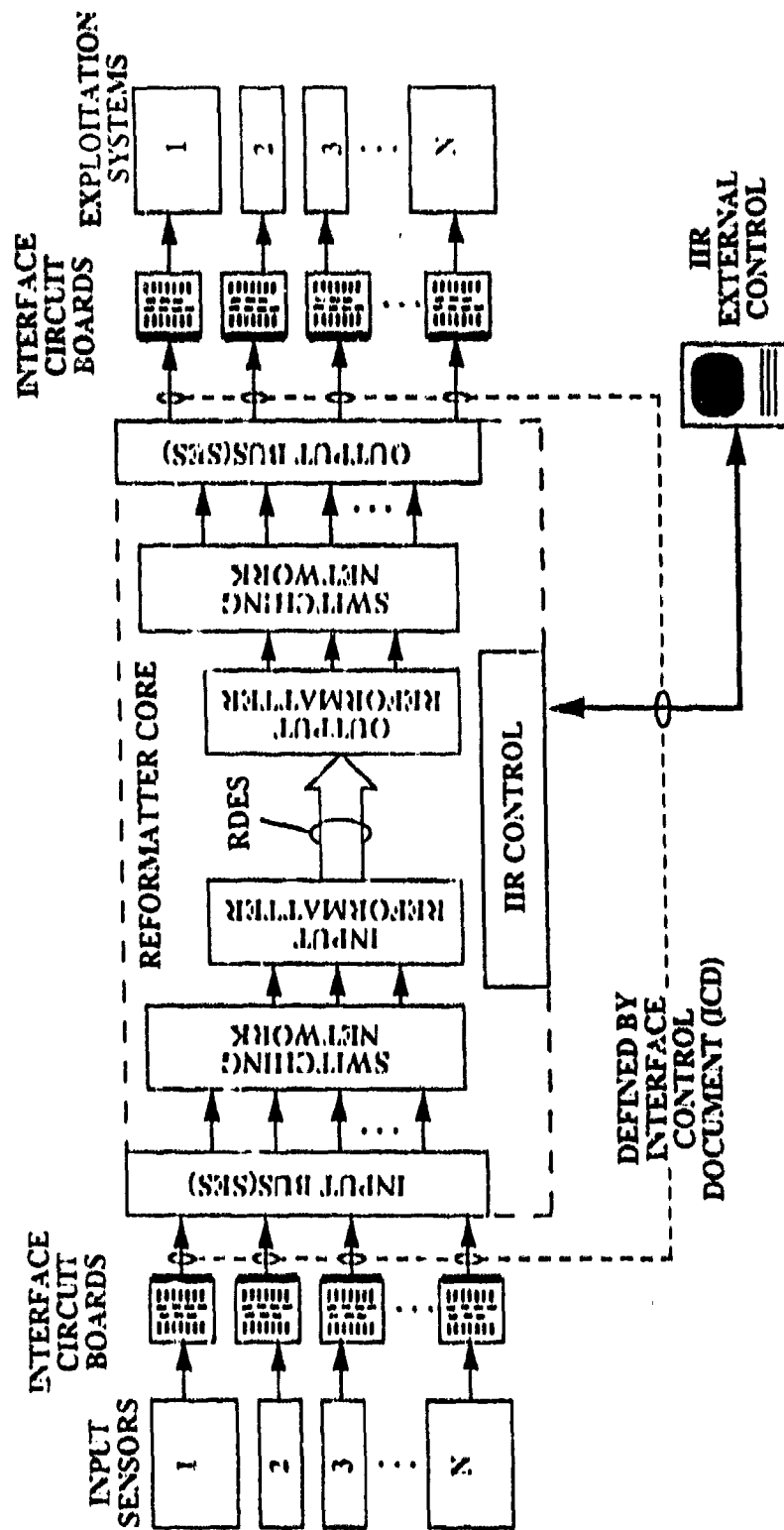
Figure 10
IIR Architecture

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An imagery/information reformatting scenario would begin with acceptance of imagery and auxiliary information from the source transport device in unique formats by the I/O interface module. The I/O interface module converts the data to formats compatible with the I/O busses' Interface Control Document (ICD). This conversion requires numerous functions including analog-to-digital conversion (or vice versa), multiplexing/demultiplexing, data rate matching, compression/decompression, filtering, etc. The I/O bus transports the source data to the core where software format configuration files are programmed to recognize the information source. Once the source data is identified, the core further reformats the data into an imagery/auxiliary data "common format". At this point, any additional auxiliary data required by the destination format/system is automatically inserted. (Manual insertion is also available.) Data is then reformatted from the internal common format to an ICD compatible format for transport via a bus to the I/O interface module. The I/O interface module, which is connected to the destination transport device (or directly to a host system imagery processor), then performs the necessary functions to convert the data to the specified destination format.

The addition of new sensors requires only the development of protocols to and from the common format. There is no need to develop multiple direct conversion methods from a new source format to every destination format. All that is needed is a method to convert the source format to the common format, and/or from the common format to a new destination format. Thus, once in the common format, data from any unique sensor source can be reformatted to a common format and then transported to any specified destination system.

The IIR is designed to perform simultaneous conversions via three parallel routes through the core. This is necessary for simultaneous data link and/or imagery tape download operations at an exploitation system. As a result, image interpreters can meet their time-line requirements for each mission, not just for the first one received.

b. **A PROCESSOR ADAPTABLE TO MULTIPLE SAR SYSTEMS.** The final element in the Air Force's architecture for interoperability applies to imagery provided by SAR systems. The architecture identifies an equipment and standards development effort to provide the means to process SAR sensor system data, regardless of the system used.

SAR systems differ from other imagery systems in that they utilize radar doppler phase history data. The doppler phase history is a record of the phase changes of successive radar returns from a given target as a SAR sensor system moves longitudinally along the target. As each radar pulse illuminates the target and is reflected back to the SAR system, its frequency is recorded. Due to the doppler effect, the reflected frequency changes as the position of the target

relative to the antenna changes within beam. Recording this frequency change over time provides the doppler phase history of the target. This phase history data is correlated to produce high resolution radar imagery. To date, each SAR system has its own unique correlation (and exploitation) system. This situation causes a proliferation of correlation and exploitation systems, and a total lack of interoperability among SAR systems.

The interoperability architecture identifies the need for an adaptive SAR processor which can, with minimum reconfiguration, produce imagery from a wide variety of SAR sensor systems in existence, in development, and which will be developed in the future. The program for an adaptive SAR processor is a NATO sponsored cooperative U.S. - German effort.

SECTION III

COMPLEMENTARY NATO ARCHITECTURE

In 1986, NATO Air Group IV (NATO's Tactical Reconnaissance and Intelligence Working Group) formed a subcommittee working group to address electronic imagery system interoperability. Many NATO nations are, like the United States, converting from film to electronic reconnaissance systems. Also like the United States, individual NATO member countries are developing unique head-to-toe collection and exploitation systems with unique data formats and components. The working group performed the "NATO Interoperability Design Study" (NIDS)[7] to determine how to establish interoperability among the new systems. NIDS results were published in September 1989. It, like CARS, concluded that the optimum point for interoperability exists between the aircraft and exploitation system.

NATO developed its own architecture for imagery interoperability. It specifies NATO programs which address the same five technical elements as described in the USAF architecture.

The complementary nature of NATO and Air Force interoperability architectures is illustrated in Figure 11. The NATO programs are:

1. STANDARDIZATION/SPECIFICATION PROGRAMS.

a. RECORDER / CASSETTE STANDARDS. NATO Study 3889/7024 provides STANAG 7024 for tape cassette standardization.[8] Developed by the Naval Air Development Center (NADC) under the authority and direction of the NATO Reconnaissance Equipment and Materials (REM) Working Party, STANAG 7024 is compatible with MIL-STD-2179A for 8mm and 19mm tape cassettes.

b. IMAGERY DATA LINK COMPATIBILITY. NATO's Interoperability Data Link Study (NIIDLS) is investigating requirements and options for developing NATO data link standards. The study is designed to identify a practical approach to achieve commonality and interoperability among existing manned and unmanned, near-real-time and real-time imagery reconnaissance systems. The study is examining existing data link systems, those in development, and potential systems. It is being completed in three phases:

- Data collection and review,
- Data analysis, and,
- Conclusions and recommendations.

NIIDLS will develop the "roadmap" for future data link system interoperability.

c. A STANDARD IMAGERY INFORMATION FORMAT. NATO Study 3889/7023 provides STANAG 7023 for an imagery and auxiliary data format architecture to interface NATO collection systems

REQUIRED
TECHNICAL
ELEMENT

NATO PROGRAM			U.S. PROGRAM
STANAG 7024	- Recorder/Cassette	-	MIL-STD-2179A
NIIDL Study	- Imagery Data Link	-	Common Data Link (CDL)
STANAG 7023	- Imagery/Data Formats	-	RDES
Cooperative IIR Effort	- Non-Std Sys Reformatting	-	Cooperative IIR Effort
Cooperative ASARP Effort	- SAR Imagery Processing	-	Cooperative ASARP Effort

ALLIED RECONNAISSANCE INTEROPERABILITY

Figure 11

Complimentary NATO - U.S. Architecture for Interoperability

to any NATO exploitation system.[9]   STANAG 7023 defines an imagery information architecture similar to and compatible with the RDES.

2.   ELEMENTS REQUIRING SOLUTIONS BROADER THAN BASIC STANDARDS.

   a.   REFORMATTING FOR NON-STANDARD SYSTEMS.   The Imagery/ Information Reformatter (IIR) program, described in Section II, paragraph 2.a. of t'·is paper is a NATO sponsored joint French - U.S. program und   both NATO and U.S. interoperability architectures.   Re‹ mmended as a result of NIDS, this effort addresses the issue of providing interoperability with current and future non-standard systems.   Not only does it alleviate the expense of redesigning existing systems when interoperability standards are developed, but also, it provides a means of maintaining interoperability in cases where more than one standard is adopted throughout the DoD and NATO. Figure 12 illustrates the application.

   b.   A PROCESSOR ADAPTABLE TO MULTIPLE SAR SYSTEMS.   The adaptive SAR processor program, described in Section II, paragraph 2.b., is a fully cooperative, NATO sponsored, U.S. - German effort.

Figure 12

Joint U.S. - French IIR Architecture
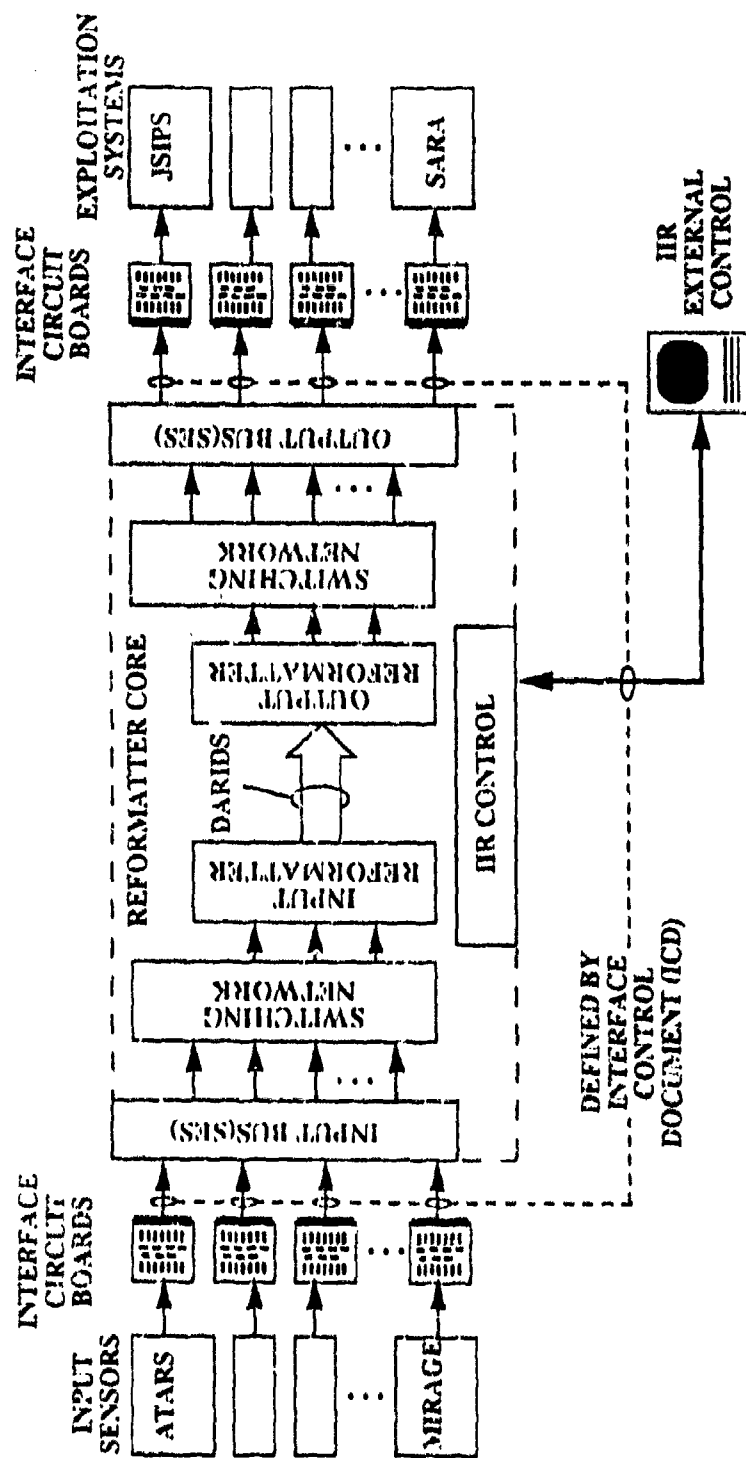
ATARS - Advanced Tactical Airborne Reconnaissance System

MIRAGE - Dessault-Bereguet Reconnaissance Platform

JSIPS - Joint Services Imagery Processing System

SARA - Station Aerotransportable de Reconnaissance Aerienne

SECTION IV

SUMMARY

The military's transition from film-based imagery sensor and exploitation systems to digital electronic "softcopy" systems provides the opportunity to significantly enhance the timeliness, flexibility, adaptability, and availability of reconnaissance/intelligence imagery assets. But to achieve this, system interoperability is required among U.S. and allied systems.

Architectures for interoperability have been developed by the United States Air Force and NATO to provide this interoperability across electronic imagery systems in-being, in-development, and those envisioned. Specific programs within these architectures are being closely coordinated, and actively pursued. The U.S. - NATO interface is taking place via established technical interfaces and is producing valuable cooperation. U.S. and NATO architectures are based upon similar logic and their programs are closely coupled, fully compatible, and where possible, joint.

The objective of the architectures and programs are to provide an interoperable, flexible "common" imagery exploitation station. Success of the programs within the architectures will provide the basis for developing such a "common" station to receive, process, and exploit imagery from any collection system, and be located or deployed where it can best serve the military commander or appropriate user because it would be independent of any particular collection system, or command and control structure.

REFERENCES

** - NO LIMITED INFORMATION HAS BEEN EXTRACTED FROM ITEMS 1, and 5 THROUGH 7.

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*DS - Distribution Statement; D-1—Premature Dissemination, DOD & DOD Contractors; B-5—Administrature/Operational Use, USGO agencies only.

APPENDIX

INTEROPERABILITY ARCHITECTURE PROGRAMS

CURRENT STATUS

(As of July 1990)

This appendix reviews the status of the individual programs which comprise the Air Force and NATO architectures for electronic imagery interoperability. Updates may be requested from Mr. Ronald B. Haynes, RADC/IRRE at (315) 330-4592 or Autovon 587-4592.

1. U.S. PROGRAMS

a. MIL-STD-2179A. The standard is in place for the 19mm tape cassette system. It is being expanded to include 8mm wide tape systems. It was developed by the U.S. Navy's Naval Air Development Center (NADC) for DoD. Certain technical aspects of the standard, concerning recording schemes, are under review by the Air Force and OSD for specific JSIPS and ATARS applications.

b. COMMON DATA LINK. The U.S. Common Data Link (CDL) program was initiated in 1989 under the auspices the Defense Support Project Office (DSPO). The architecture and implementing common modules are in use on a variety of multi-service and DoD programs. DSPO maintains control of technology insertion, architecture growth, and mission operations concepts C^3 implementations.

The basic architecture for intelligence assets using or proposing to use the interoperable C^3 approach has been documented in a family of "A" level segment specifications. A mission user's design guide is being generated. These documents will establish interface definitions and standards for multi-vendor procurement.

A family of common modules has been developed for use by DSPO and specified programs. These modules are in production configuration.

Several operational demonstrations in various platform configurations and operational scenarios have been conducted or are being conducted. To date, demonstrations have validated the CDL architectural approach and common module designs against multi-platform, multi-users, multi-sensor, worldwide collection requirements.

Documentation is available to DSPO certified users and is configuration controlled for updates based on user "feed-back".

DSPO efforts include several on-going integrations with active

intelligence assets or assets being developed. The Common Data Link Data Base currently identifies the MIST/MIDL system. Future plans call for the addition of both manned (Joint-STARS and TR-1) and unmanned (close and short range) data links.

    c. RECONNAISSANCE DATA EXCHANGE STANDARD (RDES). Final technical inputs are being received for the RDES document. RDES is envisioned to be published as a Joint Chiefs-of-Staff (JCS) Publication within a year. Portions of RDES are being used by the ATARS and JSIPS programs, and have been adopted by DSPO for the CDL's command and data processing formats.

    d. IMAGE INFORMATION REFORMATTER (IIR). This is a fully cooperative U.S. - NATO program. See paragraph 2.d. below.

    e. ADAPTIVE SAR PROCESSOR. This is a cooperative U.S. - NATO Program. It looks to take advantage of U.S. development efforts and meet the requirements of all participating NATO countries. It will produce compatible specifications which will be available to all participating parties and nations.

The adaptive SAR processor program has been proposed for execution in two phases:

- The first phase of the program focuses on near-term development and procurement of a state-of-the-art adaptive SAR processor for the purpose of providing a "common" processing capability for existing and currently defined radar sensor systems. The Electronic Systems Division's (ESD's) Joint Service Imagery Processing System (JSIPS) program has the United States' requirement to develop and procure an adaptive SAR processor by the mid-1990s. The system will handle all currently developed U.S. systems. RADC is working closely with ESD. Through established RADC - NATO interfaces, the program will provide the opportunity for NATO member countries to participate in the development of this processor. A phase I questionnaire was drafted for each NATO country wishing to participate to define their current and future SAR processing requirements.

- The second phase focuses on longer term cooperative technology development efforts among U.S. and allied laboratories. Phase II will define, develop, and demonstrate the advanced technology base required to address a radar phase history processor which not only addresses requirements found to be beyond the scope of the first phase, but will address future radar systems to be developed and deployed in the next century. Phase II will provide the basis for a cooperative venture to jointly demonstrate advanced SAR processing techniques and next-generation radar sensors and systems. Research and development efforts are envisioned to occur under the Long-Term Technology Development Memorandum of Understanding (MOU). Funding requirements will be defined as the program is planned and structured. Initial efforts will not require joint funding. Each participant country is

expected to support the effort under their own purview until precise methodology and requirements can be established into a funding program. The Office of Primary Responsibility (OPR) for Phase I is ESD's Director for Intelligence and C^3CM at Hanscom AFB, Massachusetts. The OPR for Phase II is RADC's Image Exploitation Branch (RADC/IRRE) at Griffiss AFB, New York.

2. NATO PROGRAMS

a. **STANAG 7024.** A draft STANAG 7024, "Imagery Air Reconnaissance Tape Recorder Standard" is in coordination. The 7024 effort was initiated in March 1989. A draft report is scheduled to be delivered to the NATO REM Working Party in September 1991. The draft has been presented to the NATO Study 7024 delegates from Canada (Chairman), the United Kingdom (Custodian), Germany, and the United States (NADC is the office of primary responsibility). The STANAG will provide the standard NATO approach for recorders and magnetic tape cassettes.

b. **NATO DATA LINK STUDY.** The NATO Interoperable Imagery Data Link Study (NIIDLS) was initiated in late 1989 with the issuance of a draft questionnaire for input to NATO member nations. Phase I data collection is scheduled to be complete by August 1990. Phase II data analysis overlaps Phase I and has already begun. It is scheduled to be complete by October 1990. Phase III conclusions and recommendations are scheduled to be presented in final report to NATO Air Group IV by May 1991. RADC chairs the NIIDLS Ad Hoc Working Group which was formed by Air Group IV. Contractual support is being provided by France, the United Kingdom, and the United States.

c. **STANAG 7023.** Publication of STANAG 7023 is the objective of a working group tasked by NATO to develop an imagery information exchange architecture similar to and compatible with the RDES. As a result, the Digital Aerial Reconnaissance Imagery Data Standard (DARIDS) has been developed to become an annex of "7023". The document is in draft form and undergoing a preliminary approval process by the working group. Once approved by the working group, it will be presented to the NATO REM Working Party for ratification. When ratified, the document will be forwarded to the Chairman, Military Agency of Standardization (MAS) for promulgation.

The 7023 working group consists of delegates from Canada (Chairman), the United Kingdom, Germany, and the United States (Custodian, with RADC the office of primary responsibility).

d. **NATO IMAGERY INFORMATION REFORMATTER (NIIR).** The IIR program is developing two prototype systems for tests, evaluations, and demonstrations. The first is the Joint Services IIR System (JSIIRS) for use by any U.S. and/or NATO system such as the Joint Service Imagery Processing System (JSIPS) or Mirage/SARA, but available to all NATO nations so to

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provide and demonstrate both manned and unmanned reconnaissance
system interoperability.   The second prototype is the RADC
laboratory System (RIIRS) for development and evaluation work
in their Image Processing Lab.   These systems differ only in
the I/O interface modules included.   Components common to both
systems are identical and all components are interchangeable.

The "common format" of the reformatter core was designed for
both prototype systems.   These formats are:

    - the Digital Air Reconnaissance Imagery Data Standard for
    the Joint Services IIR system, and,

    - the Reconnaissance Data Exchange Standard (RDES) for the
    RADC IIR system.

Although developed by different groups, the format standards
are structurally the same.   The difference between the two is
the number and type of systems to utilize them.

An IIR prototype demonstration will consist of:

    - reformatting (singularly and simultaneously) sensor
    mission tapes,

    - displaying the resulting imagery on an imagery
    exploitation workstation, and,

    - generation of a reconnaissance exploitation report
    (RECCEEXREP), all within operational time-line
    requirements.

These demonstrations will recommend optimum production
configurations for U.S. and NATO intelligence and
reconnaissance systems.   A final "A-specification" and an
Interface Control Document (ICD) to interface to the core will
be produced and utilized in production programs as a design
baseline.

    e. ADAPTIVE SAR PROCESSOR.   The adaptive SAR processor
program is a fully cooperative U.S. - NATO effort.   Its status
was discussed in paragraph 1.e. of this appendix.

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